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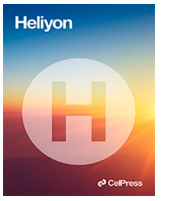

Research article

# Evaluating bank technical efficiency in SADC region

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ABSTRACT

Efficiency is generally defined as the capacity to deliver desirable results with little effort or input. A bank cannot afford to allocate limited resources at random in a competitive market. Only once the efficiency factors have been identified can resources be allocated in a conscious and effective manner. The study investigates the determinants of technical efficiency of banks in the SADC region. The study is significant in the SADC region as the block is trying to create a robust and stable banking system. This is driven by the desire to stay away from the current global financial system volatility and the region is working to develop an integrated banking system. The results show that the banks are relatively inefficient with the level of inefficiency around 40 percent. The efficiency of the banks is determined by the level of capitalisation, size of the bank, research costs and automation of the banks. The results of the study imply that that there is great scope for the banks in the SADC region to increase their efficiency. Improved efficiency will ensure banks provide services at a lower cost to clients. The study recommends adequately capitalizing banks, increasing the asset base of the banks, investing in research and the automation of the banking systems.

## 1. Introduction

When a financial system can deliver banking services and keep an eye on its stability with a minimal number of resources, it is considered efficient. Efficiency is generally defined as the capacity to deliver desirable results with little effort or input. Efficiency gauges how near a unit of production will come to reaching its production possibility frontier, which is made up of clusters of places where inputs are combined in the best way possible to yield one unit of output [1]. The study aims to evaluate the technical efficiency of banks in the SADC region.

For a variety of reasons, policymakers are interested in understanding bank efficiency. This allows them to ascertain whether market power or production efficiency is responsible for the banking sector's profitability, assess the effects of policy measures including entry and exit barriers and interest rate limits [2]. Bank efficiency lowers resource waste, boosts competition, and eventually lowers market prices for financial services [3]. Efficiency ensures financial stability, product innovation, and accessibility of financial services [4]. Increasing banking efficiency lowers the likelihood of an economic catastrophe and has a cascading effect on the entire economy [5].

A banking system that is efficient has smaller margins between lending and deposit rates, which increases demand for loans and promotes the mobilization of funds. Wide spreads have a negative impact on intermediation and skew pricing, which reduces the

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financial system's ability to support economic growth [6]. The design of monetary policy must consider the efficiency of the banking system. Policymakers can get feedback on how changes in the regulatory environment affect bank efficiency and how efficiency translates into bank performance by understanding the major efficiency transmission channels [1]. Benchmarking individual banks against global best practices and evaluating the impact of various policies are made easier because of the banking sector efficiency. The efficiency of the banks has also generated a lot of curiosity among academics [7–9].

The identification of drivers of technical efficiency has significant effect on the allocation of bank resources since resources are limited and come with opportunity cost. A bank has no liberty to randomly allocate limited resources in a competitive market. Only once the efficiency drivers have been identified can resources be allocated in a conscious and effective manner. By identifying elements that are crucial in determining the technical efficiency of the banks in the SADC Region, the study seeks to enhance the field of banking literature. Bank assets in SADC are concentrated in South Africa but reasonably dispersed throughout the other SADC nations outside from South Africa [10]. This has a negative implication for bank efficiency. It has been noted that the banking sectors in the SADC region needs to be expanded and diversified since concentration leads to inequity, which slows financial development. Most SADC countries have bank-based financial systems, and this system is heavily concentrated and dominated by a small number of institutions. The fact that most SADC nations still have weak financial sectors supports the idea that concentration reduction which is synonymous with improved efficiency is the best way to improve financial development. In light this the study evaluates the technical of banks in the SADC region.

The study is significant because SADC is trying to create a robust and stable banking system. This is driven by the desire to stay away from the current global financial system volatility. To improve trade between Member States and the rest of the world, the region is still working to develop an integrated banking system. Because of this, banks must be technically efficient to generate more outputs for a given level of inputs, including labor, capital, and technology. By doing this, they can lower expenses, boost revenue, and maintain their competitiveness in the global market. The study is novel in the sense that there is no similar study that has been done for the SADC region though some country studies have been done. There is a need therefore to understand the technical efficiency of the region rather than countries in isolation since there is a call for developing a consolidated banking system.

## 2. Literature review

The banking industry's efficiency has been examined in the literature from a variety of angles, including technical efficiency, scale and X-efficiency, allocative efficiency, and cost and profit efficiency [11–14]. An extensive range of environmental factors, including capital ownership, the country of origin of investors, banking regulations, size, and ownership structure, have been identified as having an impact on banking efficiency [15–18]. In terms of geography, some studies have looked at banking performance on a global scale, while others have concentrated on emerging economies, transition economies, developed economies, or other specific economic regions [19–22].

A study was undertaken to evaluate the impact of both internal and external factors on the effectiveness of Pakistani banks using the Data Envelopment Analysis Approach (DEA) and the Logit and Probit Regression Models [23]. The outcomes of the Logit model demonstrate that the effects of corporate governance, ultimate global ownership, and return on equity on the efficiency of the bank are statistically significant and favorable. Financial leverage and enterprise risk management have a negative impact on a bank's efficiency. A nonparametric DEA approach was used to measure and assess the relative cost-efficiency and pure technical efficiency of Ghanaian banks from 2008 to 2019 [24]. The study used both static panel and dynamic panel regression estimators to look at the factors that affect bank efficiency in Ghana. The findings demonstrate that, in comparison to the benchmark "best-practice" efficiency level, Ghana's average bank efficiency levels are significantly low. However, the findings show that since the new banking Act went into force in 2016, there have been notable gains in both the levels of cost-efficiency and pure technical efficiency. Similarly, a study was undertaken to assess factors that affect the technical efficacy of the Tunisian commercial banking sector from 1995 to 2017 [25]. The study employed a radial and non-radial bootstrap data envelopment approach to determine banking technical efficiency. The study further quantifies the impact of a group of potential factors on technical efficiency using a twofold bootstrapping regression technique. The findings show the growth rate, loan to deposit ratio, expense to income ratio, and return on equity are all inconsequential.

A two stage Data Envelopment Analysis (DEA) method was used to analyze the technical efficiency of Bangladesh's banking sector from 2008 to 2015 [26]. The Probit results of CAMEL and other bank-internal factors demonstrated that TE and PTE are explained by the CAMEL model and the CAMEL Plus model. This study discovered that among other things, bank profitability, asset quality, and capital adequacy were important determinants for efficiency of the Bangladeshi banking sector. Bank branches and bank size were important drivers of bank efficiency among internal bank parameters. The technical effectiveness of Indian banks and their determinants was evaluated using DEA [27]. The most effective banks were found to be two Indian banks, HDFC Bank, and State Bank of India, together with three foreign banks: A B Bank Ltd, Bank of Ceylon, and Citibank N A. Using the efficiency scores as the dependent variable and the following independent variables as the independents: bank size, capitalization, liquidity risk, returns on assets, interest rate, credit risk, market concentration, and gross domestic product were identified to be the significant determinants of technical efficiency.

The efficiency of the Lithuania banks was assessed employing the DEA method [28]. The technical efficiency was analysed based on the CRS assumption. The results revealed that during the 2012–2016 period the larger Lithuanian banks applied appropriate business model than smaller banks operating in Lithuania. In the same way, technical efficiency scores of Indian public and private sector banks were assessed to assess how well they are performing [29]. A one-way ANOVA was used to evaluate the ownership effect on the technical efficiency of the bank while a pooled regression model was utilized to examine the factors that affect bank efficiency. The

public and private sector technical efficiency were significantly different [30]. used the DEA approach to analyze the technical, allocative, and financial efficiency of Turkish banks. The intermediation approach was adopted for the study. The study discovered that loan quality and expenditures were important factors that were positively correlated with participation banks' efficiency and negatively correlated with conventional banks' efficiency. For the participation banks, there was no significant correlation between bank deposits and efficiency; however, in the traditional banks, there was a substantial inverse correlation.

An investigation of the factors that affect the technical effectiveness of commercial banks in Ethiopia between 2011 and 2014 was carried out [31]. The DEA methodology was adopted to estimate the technical efficiency scores. Tobit was used to analyze the factors affecting technical efficiency. As a result, it was discovered that market share, return on assets, liquidity risk, and capitalization level all have a positive and significant impact on the technical efficiency score. The technical effectiveness of rural and community banks in Ghana was examined using the binary logistic regression and data envelopment analysis based on the variable return to scale assumption were both applied [32]. According to the results of the binary logistic regression study, technical efficiency in Ghana's rural banking sector is significantly influenced by factors such as size, profitability, and bank funding quality. The rural bank's technical efficiency declines as its size and funding quality rise. It improves its technical efficiency as its profitability rises. The intermediation strategy was employed to choose the input and output variables for public, private, and international banks operating in India [33]. The results showed that foreign banks had the lowest efficiency scores and that public sector banks had better average efficiency scores than private sector banks. In terms of scale efficiency, smaller banks performed better than larger banks.

Using DEA and the super-efficiency [34], assessed the technical efficiency of Indian public-sector banks between 2009 and 2010. A Panel Data Analysis of Indian Public and Private Sector Banks Regarding Technical Efficiency and Its Determinants. According to the study's findings, banks with a larger staff were relatively more inefficient. The factors that affected the productivity and efficiency of the banking systems in seven countries in central and eastern Europe over a five-year period, from 2004 to 2008 was evaluated [35]. Stochastic frontier analysis and data envelopment analysis were used to compare the effectiveness of the banking sector in central and eastern European nations. The empirical findings demonstrate that during the studied time, banks' average efficiency increased in the countries of central and eastern Europe. The improvement is attributable to heightened competition following EU membership, the admission of international banks, as well as significant regulatory changes that made banks more productive. The efficiency of Ethiopia's commercial banks was estimated and the factors that affected it between 2014 and 2020 [36]. To analyze the data, Tobit regression, Malmquist DEA, and Data Envelopment Analysis (DEA) were used. According to the results, banks' average efficiency scores for the scale efficiency (SE), variable returns to scale (VRS), and constant returns to scale (CRS) models were, respectively, 95.5%, 99.85%, and 96.95%. The Tobit model states that as a bank's size, branch count, and credit risk increase, so does its efficiency. Bank efficiency will fall, though, as liquidity risk and the log of fixed assets rise. Consequently, it is imperative for banks to closely monitor factors that impact technical efficiency. [37]) evaluated how well Chinese commercial banks performed prior to, during, and following the global financial crisis of 2007–2008 as well as China's 4 trillion renminbi stimulus plan in 2008–2010. Technical efficiencies were estimated using fully nonparametric methods. The findings imply that technical efficiency fell during the beginning of the world financial crisis and once more in 2011–2012 following the implementation of the stimulus plan. The findings provide strong proof that big banks outperformed small banks in terms of productivity and efficiency from 2007 to 2014. Lastly, in 2007, domestic banks were generally more efficient than foreign banks; however, in 2014, foreign banks outperformed domestic banks. Using India as a case study [38], Akhtar (2023) investigates the technological efficiency of the banking sector both before and after demonetization. Based on balanced panel data for 56 commercial banks in India from 2015 to 2018, a two-stage analysis was conducted. First, the technical effectiveness of the sampled banks is assessed using the Data Envelopment Analysis (DEA) measure. Using the CAMELS framework, Tobit regression is used in the second stage to regress all bank-specific factors on the technical efficiency of Indian banks. The results of the DEA analysis point to a consistent trend of efficiency throughout the study period for the Indian banking sector. Nonetheless, a breakdown of individual banks shows that foreign banks come in second, with public banks reporting the highest overall average efficiency score. The post-demonetization performance of Indian banks appears to have been better, according to the findings of the Tobit regression. The findings of this study suggest that consolidating inefficient banks will result in beneficial synergies and could help emerging economies like India.

The performance of Vietnam's banking sector was evaluated by Ref. [39] for the years 2015–2019 and 2020–2023. The data for the input factors—running costs, deposits, assets, and liabilities—as well as the output factors—loans, revenue, and profit—are computed using the grey prediction GM (1, 1) model. Next, the relative efficiency index—which represents the performance scores of each commercial bank in Vietnam—is computed by applying the data envelopment analysis (DEA) Malmquist model to the past and future years. This allows the index to be broken down into changes in technical and technological efficiency. The management implications of this model's findings provide a framework for sustainable development by providing an overall assessment of the performance of the leading commercial bank in Vietnam. It is advised that banks create plans for the lending system's sustainable growth to stop consumers from obtaining funding from unofficial capital sources.

[40] used data envelopment analysis to examine the effectiveness of 25 banks to determine how the banks had operated under the PMJDY program. The findings of the empirical analysis suggest that public sector banks have outperformed private banks in terms of increasing financial inclusion through the PMJDY program. Furthermore, the evaluation of banks' projected and underwhelming outputs has demonstrated that a relatively small number of banks have effectively advanced the goals of the PMJDY scheme. Therefore, the analysis's overall findings indicate that inefficient banks should increase the number of underprivileged customers they serve [41]. examined the effectiveness of Indonesia's Islamic and conventional rural banks, namely Bank Pembiayaan Rakyat Syariah (BPRS) and Bank Perkreditan Rakyat (BPR). The results, obtained using a DEA approach, show that while BPR and BPRS are efficient in production, they remain inefficient in the role of intermediaries. Additionally, the Tobit estimation demonstrates that the capital adequacy ratio (CAR) and location have a positive impact on these two efficiency results. These rural banks that are present in urban

areas typically operate more efficiently than they would otherwise. Furthermore, in terms of production and intermediation, both Islamic and conventional rural banks are more efficient the higher the capital.

A literature review above has revealed that most studies used two-stage procedure estimate bank efficiency because it permits the simultaneous inclusion of variables that capture the influence of factors unique to the bank as well as those related the macroeconomy. Third, the review discovered that different efficiency scores are obtained when parametric and non-parametric techniques are applied. Fourth, the review discovered that DEA was used as a non-parametric approach and SFA was used as a parametric method in many studies. Fifth, the process for choosing input and output variables is not universally agreed upon in literature. Considering these discoveries, the study identified that there are still gaps especially on regional studies since most studies are country specific. The study specifically looks at the SADC region where there has been a dearth of studies on the efficiency of banks.

## 3. Methodology

This study aimed at examining the determinants of the technical efficiency of banks in the SADC region. The following section presents a discussion on the method of analysis, data type and sources of data.

### 3.1. Data envelopment analysis

The Data Envelopment Approach (DEA) is used in the study to assess the technical effectiveness of the banks in the SADC area. The DEA model, which considers a wide range of outputs and inputs, is used in this study to assess the technical effectiveness of banks. The model is also useful because it does not call for the outputs to take on a specific functional shape or to be aggregated beforehand. According to Ref. [42], the methodology facilitates what-if research by allowing the analyst to choose inputs and outputs based on managerial priorities. The DEA model can be used to analyze variables from various units (such staff size and transaction volume) without the necessity for standardization. The tactic has certain shortcomings. When data integrity is compromised, the DEA approach has the drawback of making it impossible to interpret the results with confidence.

DEA was created to assess relative effectiveness using data from selected inputs and outputs of various institutions known as decision making units (DMUs), such as banks [43]. A novel method of deriving the empirical estimate of relations, such as the production functions or efficient production possibility surface, is provided by the DEA, which is described as a mathematical programming model applied to observational data [43]. According to Ref. [42], the model's use of the linear programming technique enables estimation of the relative efficacy of each DMU. The efficiency frontier is then defined using the relative efficient points, and the inefficiency of other DMUs is assessed [44].

The DEA approach can be applied in one of two different ways. The other is output-oriented, while the first is input-oriented. The inputs are minimized, and the outputs are maintained at the existing levels in the input-oriented paradigm. The outputs are maximized, and the inputs are maintained at their existing levels in the output-oriented model. The assumptions used in their calculations, such as variable or constant returns to scale, have an impact on the outcomes as well. The amount of effective DMUs depends on the decision between the two on how the envelope surface is shaped. If a proportionate increase in all inputs results in a corresponding rise in output, then continuous returns to scale are achieved. The term "CCR models" refers to models that scale constant returns. The Farrell's efficiency measurement concept is developed by the CCR Model from many inputs and one output to multiple inputs and several outputs into one virtual input and output that provides the efficiency score. The CRS model is more constrained, produces fewer efficient units, and has lower efficiency scores [44].

The current study adopts the input-oriented CRS model. The productivity of a DMU (an individual bank in this circumstance) is in equation (1):

$$\boldsymbol{h_j} = \frac{\sum_{r=1}^{s} U_r Y_{rj}}{\sum_{i=1}^{m} V_i X_{ij}} \quad [1]$$

In this formula, u and v are the weights assigned to each input and output. The weights for each DMU are assigned subject to the constraint that no other DMU has an efficiency greater than 1 if it uses the same weights, implying that efficient DMUs will have a ratio value of 1.

The objective function of DMUk is the ratio of the total weighted output divided by the total weighted input and can be represented in equation (2).

$$\text{maximise } h_j = \frac{\sum_{r=1}^{s} U_r Y_{rj}}{\sum_{i=1}^{m} V_i X_{ij}} \quad (2)$$

*st*

$$h_j = \frac{\sum_{r=1}^{s} U_r Y_{rj}}{\sum_{i=1}^{m} V_i X_{ij}} \leq 1 \text{ for } j = 1, 2 \ldots n$$

The technical efficiency score is calculated using DEA model falls within the interval 0 and 1, i.e. $0 \leq \theta \leq 1$ and thus, it is a limited dependent variable.

The study chooses its inputs and outputs through an intermediation process. According to the intermediation concept, banks are not seen as providers of loans and deposit account services, but rather as intermediates of financial services. Inputs like labour, capital, and materials are used by banks to convert deposits and other cash into loans and securities (investments) and other financial products. Two outputs, total loans, and total revenue are employed along with three inputs: total labour, total assets, and total deposits. These outputs serve as a source of bank revenue and the main commercial endeavours that generate profits [45].

The current study uses the Tobit model to evaluate the determinants of bank technical efficiency in SADC region. When the dependent variable is constrained within bounds, as is the case with efficiency ratings produced from DEA constrained between zero and one (8). Tobit regression is more suited. The Tobit has an advantage over the standard linear regression model in that it produces unbiased coefficient estimates for each independent variable. Regression by Tobit operates under the presumption that your dependant variable has a normal distribution. However, you simply need to look at whether the value is above or below a predetermined threshold rather than the precise values of your dependent variable. The censoring or truncation point refers to this cutoff point.

The empirical regression model is specified in equation (3):

$$Eff = \beta_0 + \beta_1 Cap_{ij} + \beta_2 Size_{ij} + \beta_3 Res_{ij} + \beta_4 Lab_{ij} + \beta_5 Risk_{ij} + \epsilon_{it} \quad [3]$$

Where Eff is the technical efficiency score of DMUs under study and the rest of variables are as defined in Table 1. The model will be estimated using E-views 11 software. The study is premised on microeconomic determinants of technical efficiency hence it left out the macroeconomic factors.

The analysis covered the years 2010–2021 and included banks from the SADC area. The countries involved and their number of banks (in parenthesis) are: South Africa (eight), Mauritius (four), Malawi (four), Zimbabwe ([four), Zambia (five), Botswana (four), and Tanzania (four). For each bank, year data sets were used. The information was obtained from IRESS data sets, which also contained the key ratios taken from the bank-specific balance sheet and income statements for the relevant period. The selection of the candidates to be included in the study was made based on how complete the data sets for the years 2010–2021 were. As a result, the data sets were balanced quarterly panel data sets.

## 4. Results presentation and analysis

This section presents the result of the estimation of the technical efficiency of the SADC banking sector and the Tobit regression results.

Fig. 1 shows the average technical efficiency of the SADC banks throughout the period 2010–2021. The results show that the efficiency level in the SADC region hovers around 60 percent. This depicts that there is a high level of inefficiency among the banks in SADC region. Given the maximum score is supposed to be1, the level of inefficiency is around 40 percent. This implies that there is great scope for the banks in the SADC region to increase their efficiency since the current level of inefficiency means the bank customers in the region are incurring higher costs than necessary. The management of banks and bank regulators should work towards enhancing the efficiency of these institutions.

Fig. 2 shows the evolution of the technical efficiency of the individual countries in the SADC region. The results show that the technical efficiency of the banks in each of the countries have not been consistent throughout the period. The period reflects lots of inconsistency among the countries with Mauritius showing the greatest movements in the efficiency scores. Most of the countries show that there are operating around efficiency of 60 percent with a few which are consistently above this average. These results confirm the need to improve the input/output mix among the banks in the SADC region.

Before undertaking any manipulations (regressions) of the data, the study computes the descriptive statistics and correlation matrices for all banks in the sample. It is important that the econometrics results adhere to certain apriori expectations to avoid the problem of spuriousness in regression analysis.

**Table 1**
Justification of variables.

| Variable | Explanation |
|---|---|
| Capitalisation (Cap) | A banking institution which has adequate capital is essential to ensure their improved efficiency. It means that banks that are well capitalized have the capacity to undertake various initiatives which can lead to improved efficiency. |
| Bank Size (Size) | Bank size is measured by the total asset base of the bank. This is measured by the logarithm of the bank assets. A bank is more likely to make more money as its size grows. Larger banks have the advantage of having more access to outside funding sources, dealing with liquidity issues, and spreading out risk, which makes them more likely to be effective. |
| Research (Res) | The research variable is measured by the total amount of money invested in research and innovation to improve system efficiency. Market research aids banks in comprehending the needs, tastes, and behavior of their clients. This data can be utilized to create new products and services that cater to client needs and enhance the effectiveness and convenience of banking overall. |
| Labour Costs (Lab) | Labor costs are the total wages and salaries paid to bank workers and managers. Since labor expenditures are one of the key cost factors for banks, their increase has a detrimental impact on efficiency as well as performance. |
| Credit Risk (Risk) | Credit risk is the potential for a lender to lose money when they provide funds to a borrower. This is measured by non-performing loan ratio. The biggest risk to the bank's performance is credit risk. The bank's performance is impacted by the large percentage of non-performing loans on its balance sheet, which lowers the bank's profitability. |

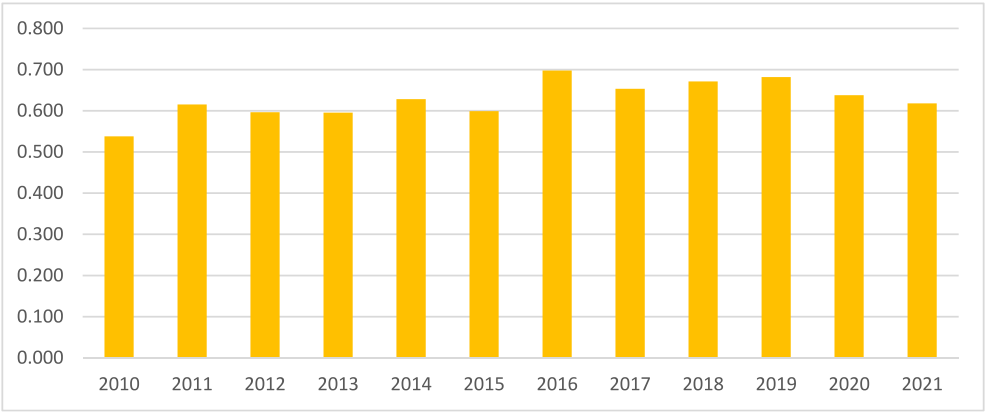


**Fig. 1.** Average technical efficiency.

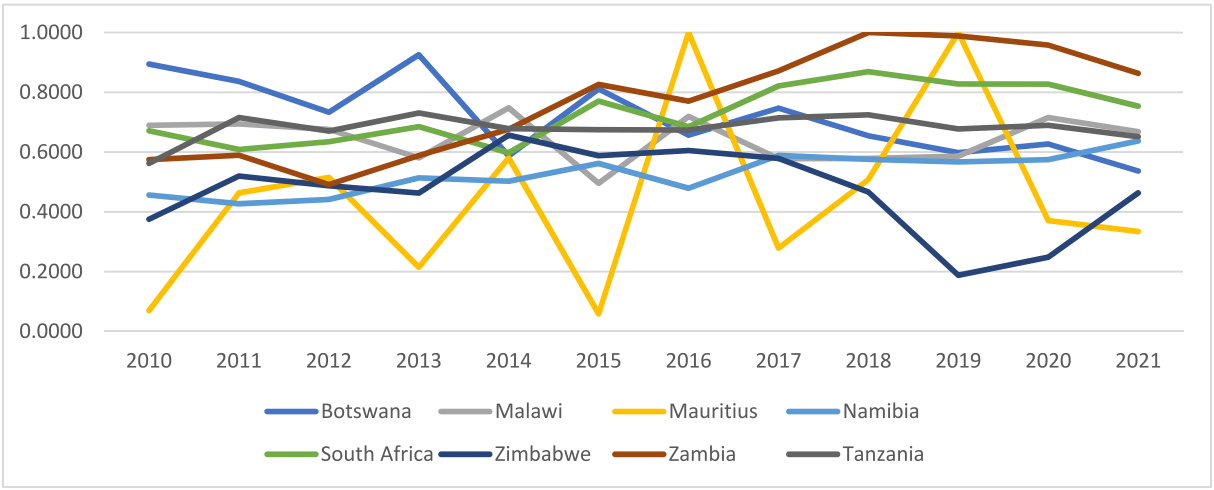


**Fig. 2.** Evolution of technical efficiency.

Table 2 presents summary statistics for equity, size, research expense, labour cost and credit risk. These are the variables of interest. All the data series display a high level of consistency as their mean and median values are within the range of maximum and minimum values of the series. Deviations of actual data from their mean value are very small, shown by low standard deviations for all variables.

There is no significant link among the variables, according to the correlation coefficient matrix (Table 3). Multicollinearity challenges arises if the correlation between the independent variables is more than 0.8 (41). All the independent variable correlation coefficients were under 0.8. All the variables were considered when estimating the regression model.

The study sought to evaluate the determinants technical efficiency of commercial banks in the SADC region. The Tobit (censored) regressions with boundaries of zero at the left and one at the right are applied and the results are shown in Table 4. Diagnostic of the study the model is fine since Akaike information Criteria, Schwartz criteria and Hannan-Quinn criteria are low paving way for the discussion of the results.

The results show that bank capitalisation has got a positive relationship with technical efficiency. A unit increase in bank

**Table 2**
Descriptive statistics.

| | Cap | Size | Res | Lab | Risk | Eff |
|---|---|---|---|---|---|---|
| **Mean** | 0.0828 | 0.6715 | 0.0015 | 0.0139 | −0.0041 | 0.6404 |
| **Median** | 0.0127 | 0.0756 | 0.0000 | 0.0025 | −0.0001 | 0.6524 |
| **Max** | 1.2797 | 11.7320 | 0.0005 | 0.2938 | 0.0344 | 1.0000 |
| **Min** | −0.2789 | 0.0000 | 0.0000 | 0.0000 | −0.1533 | 0.0007 |
| **St Dev** | 0.1679 | 1.3402 | 0.0006 | 0.3047 | 0.0127 | 0.2454 |
| **Skewness** | 3.3825 | 3.6716 | 4.6020 | 5.3019 | −6.3701 | −0.5785 |
| **Kurtosis** | 17.4600 | 20.0502 | 25.0853 | 38.4027 | 57.7108 | 3.1354 |

**Table 3**
Correlation matrix.

| | Equity | Assets | Research | Labour | Risk |
|---|---|---|---|---|---|
| **Cap** | 1 | | | | |
| **Assets** | 0.6779 | 1 | | | |
| **Research** | 0.0769 | 0.1258 | 1 | | |
| **Labour** | 0.5770 | 0.5506 | 0.03778 | 1 | |
| **Risk** | −0.4866 | −0.4866 | -o.09190 | −0.4293 | 1 |

**Table 4**
Tobit Regression (Efficiency dependent variable).

| Variable | Coefficient | P-Value |
|---|---|---|
| C | 0.6223*** | 0.0000 |
| Cap | 1.6347*** | 0.0013 |
| Assets | 0.5716*** | 0.0000 |
| Research | 12.7243*** | 0.0065 |
| Labour | −1.7242*** | 0.0000 |
| Risk | 2.4560 | 0.3930 |
| Mean Dependent | 0.6545 | |
| SE regression | 0.4344 | |
| Akaike Info Criteria | 0.2681 | |
| Schwartz criterion | 1.9242 | |
| Hannan-Quinn Criteria | 1.8909 | |

capitalisation increases technical efficiency by 1.63 units. This implies that well capitalized banks are technically efficient as compared to those that are less capitalized. This implies that shareholders of banks should ensure that banks are properly capitalized so that they improve their performance. Studies [27,31], also found similar results that bank capitalisation was a significant determinant of technical efficiency.

The size of the bank has a positive effect on technical efficiency. An increase in bank size by 1 unit increases technical efficiency by 0.5 units. The bigger the bank the more technical efficiency it is. This argument can be explained by the economies of scale. As the bank size increases it starts enjoying economies of scale which reduces its costs. The reduction in cost then leads to improved efficiency compared to those small banks who will incur high costs of operations. Studies [ 25, 27] support the findings that size has a significant effect on the technical efficiency of the banks.

Research costs are positively related to the technical efficiency of banks. A unit increase in research costs increases technical efficiency by 12 units. The magnitude of the coefficient of research costs shows that it is the most significant determinant of technical efficiency. The reason behind the positive relation is that as a bank increases its investment in research, it identifies cheaper and efficient ways of providing the services. As the processes of producing output become simplified it leads to lower costs of production which then enhances the efficiency of the bank. It is imperative that banks remain consistent in undertaking research to continuously improve their technical efficiency.

Labour expenses are a drain to the banks as they constitute the greatest expense line. The labour expenses have a negative effect on bank technical efficiency. A unit increase in labour cost reduces efficiency by 1.72 units. It implies that the greater the labour cost incurred by a bank the lower the technical efficiency. The results are supported by Ref. [34] who assessed the technical efficiency of Indian public-sector banks and established that banks with a larger staff were relatively more inefficient [30]. also identified that cost had a negative effect on technical efficiency. Labour cost containment hence improves the technical efficiency of the banks. The argument can be further supported by the fact that automation of systems which reduces the amount of labour required has the greater potential to improve the technical efficiency of the banks. With automation of the banks increase there is greater scope that banks should become more and more efficient since the cost of automation are usually once off unlike that of labour which is done frequently. A proper balance though is required between amount of automation and labour.

The robustness check for the model was further estimated using a dynamic panel data model that is based on the reliable estimates for such models provided by Arellano and Bond's (1991) Generalized Method of Moment (GMM) estimator. The potential endogeneity of the variables, the dynamic relationship between the dependent and independent variables as both are influenced by the prior values of each other, and unobserved country-specific effects are the main factors that influenced the choice of the GMM model. To get around these possible problems, we specify the dynamic panel GMM estimator that Arellano and Bond (1991) suggested.

The results of the GMM model shown in Table 5 mirrors those obtained using the Tobit regression method. The results shows that technical efficiency of the banks is determined by the technical efficiency from the previous year, capitalisation of financial institutions, size of the banks, outlay on research and labour costs.

The limitation of the study is that the study concentrated on micro econometric analysis hence left out some macroeconomic variables since the main thrust was to check on how managers can improve technical efficiency. The study was limited by the data availability and the adoption of a single method to measure technical efficiency. There is need to do a comparative analysis of the various methods for robustness' sake.

**Table 5**
Arellano Bond Dynamic Estimation GMM (Efficiency dependent variable).

| Variable | Coefficient | P-Value |
|---|---|---|
| C | 0.1183*** | 0.0000 |
| Cap | 2.1870*** | 0.0000 |
| Assets | 1.1423** | 0.0019 |
| Research | 4.3673*** | 0.0065 |
| Labour | −0.1473** | 0.0000 |
| Risk | 2.4560 | 0.6571 |
| Teff | −1.1659 | 0.0000 |
| Wald Chi2(2) | 420.62 | |
| Prob (Chi2) | 0.0000 | |

## 5. Conclusion

The study evaluated the technical efficiency of banks in the SADC region. The main thrust of the study was to assess how technical efficiency has evolved over the period 2010–2021. The essence of such assessment is to check whether banks can offer services to their clients at a lower cost, or they are being punitive to their clients by being technically inefficient. The study established that banks in the SADC region are technically inefficient with an opportunity to increase their efficiency by 40 percent. It has also been established that efficiency of banks is driven by research, capital levels, and labour costs. The implication of the study is that bank specific factors have a significant influence on banking efficiency hence managers should ensure that variables within their control such as labour costs, capitalisation levels and outlay on research are managed to ensure efficiency is improved. The study has shown the major factors that can ensure services are provided at reasonable cost which will ensure banks are proofed against current global financial system volatility. Working towards these factors will ensure banks can lower expenses, boost revenue, and maintain their competitiveness in the global market. The study recommends that banking institutions and central banks in the SADC region should ensure they devote more resources to research, automation of systems and capitalize institutions adequately to ensure banks are able to absorb shocks. Future studies should try to decompose the technical efficiency into its constituents' parts of pure technical efficiency and scale efficiency to identify the dominant factor affecting the banking sector. Further studies should also look at the role of country risk, country governance, political risk and governance given the differences in these factor among SADC countries.

## Data availability statement

The data for the study will be available upon request.

## CRediT authorship contribution statement

**Sanderson Abel:** Writing – review & editing. **Julius Mukarati:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Conceptualization. **Robson Manenge:** Writing – review & editing, Software, Methodology, Data curation. **Pierre Le Roux:** Writing – original draft, Software, Methodology, Investigation.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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